A Study of Arousal Classification Based on EEG Signal with Support Vector Machine Method

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***Abstract*---The development of Brain Computer Interface technology nowadays has spread out in a case of classifying emotions based on brain signal (EEG) in human, which in this work using a set of secondary data from DEAP. One of the emotion parameters being focused on here is arousal with the range from low (uninterested) to high (excited). This study is applying Principal Component Analysis as the feature extraction. Not only that, feature extraction also being done statistically. As for feature classification is using Support Vector Machine with the maximum accuracy that only able to reach 59,4% which still needs improvements in the system for future works.**

***Keywords*---EEG, PCA, SVM, Emotion Classification**

I. INTRODUCTION

The human emotion fluctuated depends on the situation and/or condition that is currently happening to the human being. In other words, the physiology state of the related human being has a big impact on the fluctuation itself. In this study, 32 participants being investigated based on DEAP: A Dataset for Emotion Analysis Using EEG, Physiological and Video Signals. Based on the dataset, for the EEG channel selection out of 40 channels only 32 chosen to be used. The channel positions shown in Fig. 1 where Coan et al. [1] indicated that left frontal brain activity associated in positive emotions relatively, whereas the right frontal brain activity associated in negative emotions.

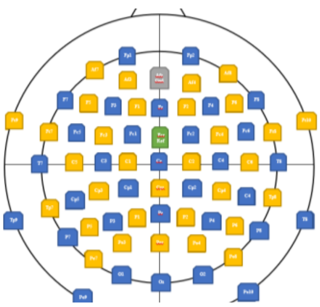

Fig. 1. EEG channels attachment position on the human scalp.

In this work, Principal Component Analysis (PCA) being chosen as the feature extraction by taking the diagonal eigen value for investigation, also statistical features like entropy and kurtosis to complete the feature extraction. As in feature classification, Support Vector Machine (SVM) is being investigated to finish up the study on finding the effectiveness of methods in emotion recognition based on EEG signal.

II. METHOD

The secondary dataset being used from DEAP has been down sampled to 128 Hz from the original sampling rate for the recorded data is 512 Hz. Not only that, dataset also been pre-processed where the artifacts from EOG removed and a band pass filter 4.0 – 45.0 Hz applied to the raw data [2]. Thus, in this study, the already preprocessed data being used here which contains 32 participant files with 40 trials and 32 channels each participant.

A. Feature extraction

PCA is being used to reduce the dimension of the data as minimal as it could be without changing or cropping the characteristic and/or information of the data itself by defining a new coordinate of the data [3]. The basic concept of PCA itself illustrated in Fig.1. Later in this work, PCA output known as diagonal eigen value will be included in one of the feature extractions.

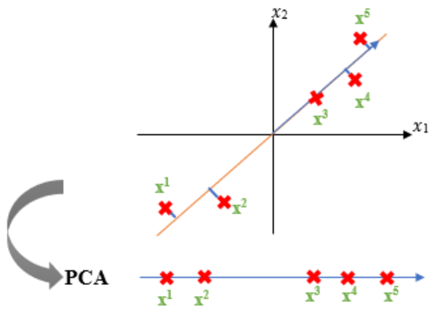

Fig. 2. The basic concept of Principal Component Analysis where it finds new coordinates with a lower sub-dimension.

Moving on, the statistical feature extraction parameters such as entropy and kurtosis also being investigated along the side of the PCA parameter.

a. Entropy

Shannon defined entropy as a technique with equation that provides a way to estimate the average minimum number of bits required to encode a string symbols based on the frequency of the symbol itself. The entropy formula shown in Equation 1.

$$H(x) = -\sum_{i=0}^{N-1} p_i log_2 p_t \qquad (1)$$

The probability of character the i is being appeared in the stream defined as p_i.

b. Kurtosis

To differentiate between dataset that has high kurtosis and low kurtosis can be seen in the peak position towards the mean. High kurtosis dataset will have their peak distinctly close to the mean, meanwhile low kurtosis dataset has their peak as a flat top close to the mean.

$$Kurtosis = \frac{\sum_{i=1}^{N} \frac{X_t - \bar{X}}{N}}{s^4} \quad (2)$$

Based on Equation 2, $\bar{X}$ is defined as the mean value, N is the sample size, and s is the standard deviation.

B. *Support Vector Machine (SVM)*

SVM is a classifier in a non-linear field and in the use of kernel mapping function is capable to make the input feature vectors transformed into a generally higher dimensional feature space [4]. The aim of SVM itself is to separate training data in a shape of binary set by means of hyperplane position that is quite distant in a maximum value from the two classes.

The hyperplane's margin and the maximum point are being measured to find the best separator of the hyperplane between two classes [5]. As illustrated in Fig. 3, hyperplane C is chosen to be the best one since it has the highest margin out of three. To choose highest margin has an impact on preventing miss-classification [6].

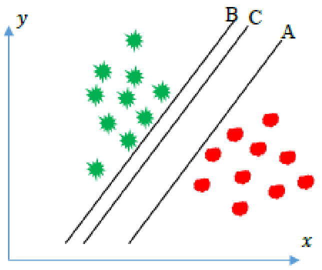

Fig. 3 One of the models in finding the best hyperplane.

III. RESULT AND DISCUSSION

In this study, the original preprocessed data are being converted to a two-dimensional data and being saved as temporary files to be loaded later on the feature extraction. As all the features has been extracted, there are now 3 features which is the mean value of diagonal eigen, entropy and kurtosis, also participant ratings as the result with size of 1280x4 in .xls file. Some of the result can be seen in Table 1.

Table 1. Feature extraction data table along with the arousal class based on ratings.

CR1	CR2	CR3	Arousal Class
15.1276	2.197951	3.743994	Uninterested
1257.422	1.343815	21.46953	Excited
34.29626	1.911764	6.998433	Excited
4935.412	1.165078	13.48152	Excited

The participant ratings itself were given by the participant in the range of 1 – 9 divided into two classes as low arousal (1 – 5) and high arousal (5 – 9). Here we have in Table 2, the result of the trained data with SVM applied giving a 59.4% maximum accuracy in validation of 10% held out.

Table 2. Accuracy of the trained data with SVM and 10% held out validation.

SVM Type	Accuracy (%)
Linear	59.4
Quadratic	53.1
Medium Gaussian	58.6
Fine Gaussian	58.6
Coarse Gaussian	59.4
Cubic	43.8

IV. CONCLUSION

Based on the results, this system still needs improvements to get better accuracy and efficiency as a classifier. For future works, perhaps combining and finding the correlations between the other feature extraction (skewness, variance, standard deviation, harmonic mean, and interquartile range) might be able to result better accuracy than using only 3 features extraction.

REFERENCES

[1] M. M. Sorkhabi, "Emotion Detection from EEG signals with Continuous Wavelet Analyzing," *Am. J. Comput. Res. Repos.*, vol. 2, no. 4, pp. 66–70, 2014.

[2] S. Koelstra *et al.*, "DEAP: A Database for Emotion Analysis; Using Physiological Signals," *IEEE Trans. Affect. Comput.*, vol. 3, no. 1, pp. 18–31, 2012.

[3] A. P. Gosavi and S. R. Khot, "Emotion Recognition using Principal Component Analysis with Singular Value Decomposition," *2014 Int. Conf. Electron. Commun. Syst. ICECS 2014*, 2014.

[4] K. Aida-Zade, A. Xocayev, and S. Rustamov, "Speech Recognition using Support Vector Machines," *Appl. Inf. Commun. Technol. AICT 2016 - Conf. Proc.*, pp. 86–91, 2017.

[5] I. Wijayanto, A. Rizal, and S. Hadiyoso, "Multilevel Wavelet Packet Entropy and Support Vector Machine for Epileptic EEG Classification," *4th Int. Conf. Sci. Technol.*, pp. 9–14, 2018.

[6] A. Ng, "Support Vector Machines," *Intell. Syst. their Appl. IEEE*, vol. pt.1, no. x, pp. 1–25, 2000.